

In Table 3C, Instantaneous WATER Measurements Coastal Waters and Ocean, and in Table 3D, Instantaneous WATER Measurements Near Clio 02-PLU-89, the data were used to indicate whether there may have been any electrolyte present, usually via the conductivity value, which helped explain wire corrosion or lack thereof. Before field excursions, we calibrated the YSI portable instruments at the Translab Water Quality and Biology lab as well as on-site, as recommended by the manufacturer, by applying local temperature and elevation corrections.

### **ULTIMATE TENSILE FORCES - VALIDITY of RESULTS and CRITIQUE**

A scatter plot is presented in Figure 2 as Chart 1 on page 10, and it shows the ultimate tensile forces BEFORE exposure of the 7 main products, products 1 through 7. Chart 1 shows relatively uniform values with some variability. BEFORE means and other descriptive statistics are listed in Appendix B. None of the mean ultimate tensile forces, either BEFORE or AFTER exposure were charted, however the values are listed in Tables 3E-1 through 3E-9 and 3E-11, which correspond to sites where we collected and broke wires. Taken as a whole, the AFTER values ranged from virtually no variation to some very large differences, when compared or contrasted to BEFORE values. Large differences occurred where there were severe local exposures.

The tensile test results and student t-tests are tabled and presented with each site discussion. We can restate the null hypothesis of the student t-test as : **Is there a difference between wires BEFORE and AFTER exposure at field sites ?** In Tables 3E-1 through 3E-9 and 3E-11, we sometimes calculated an apparent gain of mean tensile force of wires from a full-scale facility AFTER exposure. This is not what anyone would normally expect. Some of those comparisons are likely NOT valid, unless the test panels and full-scale facilities came from the same production runs. In most cases they did not. We acknowledge that the BEFORE data set was from a relatively small sample of 38 tests, and that the coefficients of variation were less than 6 percent, relatively small variations. Such results may indicate good quality control in manufacturing of wire. However, the BEFORE data represent wire samples from only two gabion panels. It is not likely that those two panels encompassed the range and variability of wires from the universe of wires that were produced for gabions, and especially of the wires with which the full-scale gabion facilities were actually built. While we used the 5 percent level of significance, (size of the rejection region), we feel there may be instances of statistical errors of Type I, where we rejected the null hypothesis when it was true, and also of Type II, where we may have accepted the null hypothesis when it was false.

Some of the gains in mean ultimate tensile force AFTER exposure may indeed be valid. When there was a relatively small apparent gain, there a few reasonable explanations to consider. One is the possibility of strain aging [Reed and Aguilar, reference 17]. Another is that there were larger wire diameters in the full-scale facility as opposed to the test panels. In prior research, it was reported that within test panels among products 1 through 7, there were average diameters that were less than the minima that are required by the Caltrans material specifications [Racin, reference 6]. Another explanation for small apparent gains in ultimate tensile force is the likelihood of different elemental mixtures from one heat (batch of steel) to the next. Various scrap metal products may be used to manufacture the wire, so some batches may produce

## SITE 7

The exposure of site 7 is along the shore of the Pacific Ocean in Monterey County. The average annual rainfall as measured at Willow Springs is about 27 inches. This part of the California coast is often foggy, and storm waves can sometimes reach above 25 feet, as reported by one observer. As reported in [Racin, reference 5], there are four full-scale gabion facilities of product 5 that were completed in 1985. There are two rock slope protection (RSP, also called riprap) revetments to protect the toes of roadway slopes from wave erosion. The prominent rock formation in photos 84, 86, 87, and 98 is locally called Shale Point, so we called the revetment north of Shale Point “north RSP”, and we called the revetment south of Shale Point, “south RSP”. The 720-foot long south RSP is a deepwater location, where waves break directly on the revetment. The 600-foot long north RSP is a shoal water location, where waves break on the beach during low tide, and on the revetment during high tide. Both revetment cross sections are sloped at 1.5H:1V and consist of a geotextile, a 1-foot high PVC-coated gabion mattress, and an 8-foot thick layer of 8-ton rock. The 1-foot high mattresses were substituted for a California Bank and Shore “standard” three inner layer design of RSP, to reduce the total thickness by 7 feet (normal to finished slope). The two gabion retaining walls buttress the toes of previously over-steepened slopes that were naturally eroded by wave action. The finished slopes above the walls are 1.5H:1V. The south wall is about 400 feet long and the north wall is about 550 feet long. Each wall is 7 tiers high, with the first 2 tiers below ground as shear keys. The buried bottoms of each wall are at about 4-feet above sea level, and both walls are protected by rocky beaches from normal daily high tides and waves, so they only get direct wave attack during storms with above-normal high tides and waves. The wall faces are stepped 3-feet wide in cross section. As reported in [Hoover, reference 4], test panels of product 4 (zinc-coated mesh) and product 5 (PVC-coated mesh) were attached to the walls at various elevations in 1986. No test panels were attached to the gabion mattresses under the 8-ton RSP, and no additional test panels of other products were attached to the walls.

Both the south and north sea walls and the roadway slopes are OK, even though many wires are broken on the treads of the step-faced walls. No empty baskets were discovered in either the walls or the mattresses under the RSP. Of the test panels, zinc-coated wires are corroded, undamaged PVC-coated wires were OK. PVC-coated mattresses under the 8-ton RSP are also mostly OK. Severe storms in January 1997 caused about 40 slides along the Pacific Coast Highway. One slide about a mile north of the north gabion wall was called the Duck Pond slide, [Duffy, reference 19], and about 9 acres (1.5 million cubic meters or 4 million tons) of earth moved. The toe of the slide was in the ocean, and as reported by Jim Krenkel of the Caltrans Willow Springs Maintenance Station, the normally rocky beach below the gabion walls filled with a 10-foot thick layer of slide material, and after 2 or 3 days the beach returned to its prior level. As seen in the photos, there was displacement of a few less-massive rocks in the RSP revetments, but overall, the revetments are OK.

As confirmed by Mike Eul of the Willow Springs Maintenance Station in May 2001, after 16 wet seasons the 2 gabion walls and the 2 RSP revetments are mostly OK. During the wet season of 2000-2001, there was one storm with above normal waves that displaced some of the rock of the north RSP, and some mattresses were exposed.

Because site 7 received storm waves, splashes, and direct salt spray on very windy days, there was advanced atmospheric corrosion of zinc-coated test panel wires. We do not have precise counts of the number of storm events that caused waves to splash and run-up on the walls, however we estimate that those were not frequent occurrences. If there were many prolonged direct wave attacks, soil test results (Figure 3-3 and Table 3B) indicate that there would most likely have been abraded wires along the wall faces. In the wave breaking zone on the north RSP, measurements of chlorides, salinity, and dissolved oxygen were high, as we expected. See Table 3C.

The tensile and t-test results in Table 3E-7 do not appear to be too unusual. Undamaged PVC-coated wires are performing well, because exposure to waves is not constant or direct. The walls are attacked from high seas during storms (and not twice daily at high tide). Wave energy is dissipated by the rocky beach. Zinc-coated wires are doing as expected, corroding and losing strength. For PVC-coated wires, the apparent gains of AFTER wires (remnant of mattress found on beach near 8-ton riprap and south wall test panels) are likely from larger diameters than BEFORE wires, as at site 6. Also, the mattresses were from different manufacturing runs than the test panel BEFORE wires. Therefore, the tabled values should not be considered as absolute, valid comparisons.

## 6. IMPLEMENTATION

### PAPERLESS REPORT

The report was intended for distribution as a paperless report. The entire report is in **pdf** (portable document file) format, and it is readable with Adobe Acrobat ® Reader, version 4 or higher. A paper report (hard-copy) is available for loan at the Caltrans Headquarters Library, 1120 N Street, in Sacramento, CA. A CD-ROM may be obtained from the author or from the Office of Pavement Research Management, Technology Transfer Branch in the Division of New Technology and Research.

The hyperlink <http://www.dot.ca.gov/hq/oppd/hydrology/gabion.htm> (single left-click or you may be able to right-click for opening options) should connect you to the Caltrans Internet web site, where there are instructions with hyperlinks for downloading the entire paperless report and some general guidance. If you connect via the Caltrans DESIGN DIVISION web site <http://www.dot.ca.gov/hq/oppd>, click on "Manuals & Guidance", then "Other Publications", then the report title Gabion Mesh Corrosion.

The report may also be ordered from the National Technical Information Service (NTIS). See box 18 on the Technical Report Documentation (Abstract) page for the NTIS phone number and address. When ordering from NTIS, cite the government accession number (PB2001-102895) in addition to the report title, subtitle, and authors.

### PRINTED COPY

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1. If your printer does not have Arial True Type font, then under "font selection" before you click the Print button, you may be able to select the "Download as soft font" option. Or Helvetica seems to be an acceptable font substitution for Arial.
2. If the copy will be 3-hole punched, and if you are printing from Adobe Acrobat ® Reader 4.0, before you click the Print button, look at the print menu options. Check the "Fit to page" box and then print the image. It will be 95 percent of full size, and the 3-hole punch will not remove much text or photo image.
3. Similar to 2, for actual image size, only check the box labeled "Print as image".

### CONTACT the AUTHOR

If you know of a failure or maintenance and re-construction activities at any of the gabion sites mentioned in this report, then after contacting the local Caltrans District Office staff, please contact the principal author. Also, contact the author, if you own and maintain gabions and can add to knowledge of gabion performance and service-life.

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